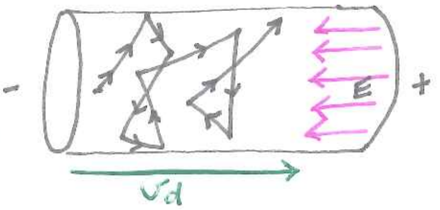
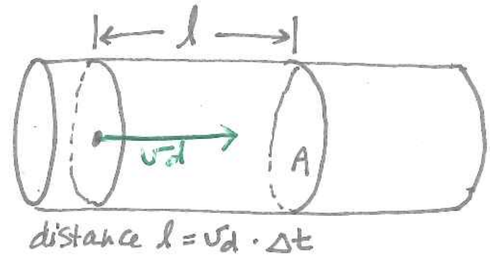
Giancoli example 18-9





A copper wire, 3.20 mm in diameter, carries a 5.0 A current.

Determine:

v_d = DRIFT VELOCITY = E, field in a wire initially accelerates e but they then reach a somewhat steady v_{avg} (due to collisions with atoms in the wire).

a) The drift speed of the free electrons

b) The rms of the electrons assuming they behave like an ideal gas. Assume that one electron per Cu atom is free to move (the others remain bound to the atom).

a) X-sectional area of wire $= \pi(1.6\times10^{-3}\,m)^2 = 8\times10^{-6}\,m^2$

Density of Cu e^- = Density of Cu (1 free e^- per atom) $= 8.9\times10^3\ kg\cdot m^{-3}$

1 mole Cu atoms (Same as # Cu e^-) $= 63.5\,g = 6.02\times10^{23}\ e^-$ of Cu

find # e^- (free) per unit volume $= n = \frac{6.02\times10^{23}\,e^-}{.0635\,kg} \times 8.9\times10^3\,\frac{kg}{m^3}$

$n = 8.4\times10^{28}$ free $e^- \cdot m^{-3}$

$I = neAv_d$

macro current (Amps) → I; Area (m^2) → A; Charge $1e^-$ (C) → e; Drift velocity (m/s) → v_d

$v_d = \frac{I}{neA} = \frac{5.0\,A}{(8.4\times10^{28}\,e^-\cdot m^{-3})(1.60\times10^{-19}\,C)(8\times10^{-6}\,m^2)}$

$v_d = 4.7\times10^{-5}\,m/s$ $\simeq .05\,m/s$ (fairly slow)

b) $v_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3(1.38\times10^{-23}\,J\cdot K^{-1})(293\,K)}{9.11\times10^{-31}\,kg}} = 1.15\times10^5\,m/s$

much faster

T = temp in K (20+273)

k = Boltzmann's const

m = mass of 1 e^-